Moiré physics in 1D and 2D

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Moiré patterns emerge when two periodic structures are overlaid and fully characterized by the twist angle between them. The resulting material is a new entity and exhibit emergent properties, drastically different from those of their components. In this talk we address the questions: what are the further degrees of freedom that emerge when moving from 2D to 1D? Are these experimentally accessible and usable in nano-devices? How do the combined effect of twist angle and strain modify the hybrid material properties in 2D?

To answer these questions, we investigate interference effects in finite sections of 1D moiré crystals using the Landauer-Büttiker formalism within first-principles and tight-binding approximation [1]. We address interlayer transport in double-wall carbon nanotubes and demonstrate that wave function interference is visible at the mesoscale: in the strong coupling regime, as a periodic modulation of quantum conductance and emergent localized states; in the localized-insulating regime, as a suppression of interlayer transport, and oscillations of the density of states. The interlayer transmission between strongly coupled metallic nanotubes is limited to either $1G_0$ or $2G_0$. Our results could be exploited to design quantum electronic devices, e.g. non-electric switches based on chiral nanotubes. Most importantly, we clarify the origin of the so-far unexplained $1G_0$ quantum conductance measured in multi-wall carbon nanotubes [2, 3]. Further, we show that the relative orientation angle between graphene and TMDs can be exploited to tune proximity induced SOC in graphene and create ideal conditions for next-generation memory storage based on spintronics [4].

References

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Figures

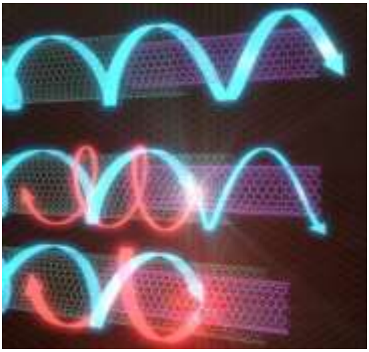

Figure 1: Quantum Conductance in double wall CNTs can proceed undisturbed and plateau to the conductance quantum (G_0), partially transmitted, or completely blocked, depending on the spatial overlap of the two carbon nanotubes and their nature (chiral vector). Image: Damaso Torres, ICN2 Barcelona.